EXPO

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University of Idaho

College of Engineering

# Data Acquisition System for Synchronous Generator Transient Performance

## Sponsored by

SEL SCHWEITZER ENGINEERING LABORATORIES

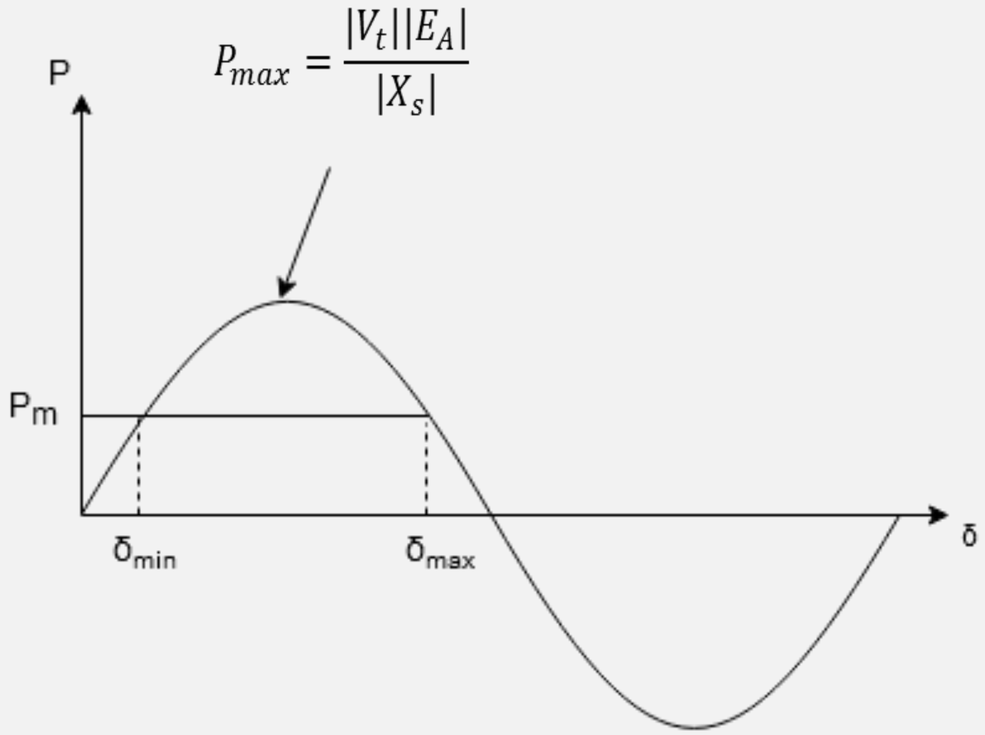
# Agenda

- Project Goal
- Specifications
- Project Topology
- Project Learning & Results
- Project Budget

# Problem Statement

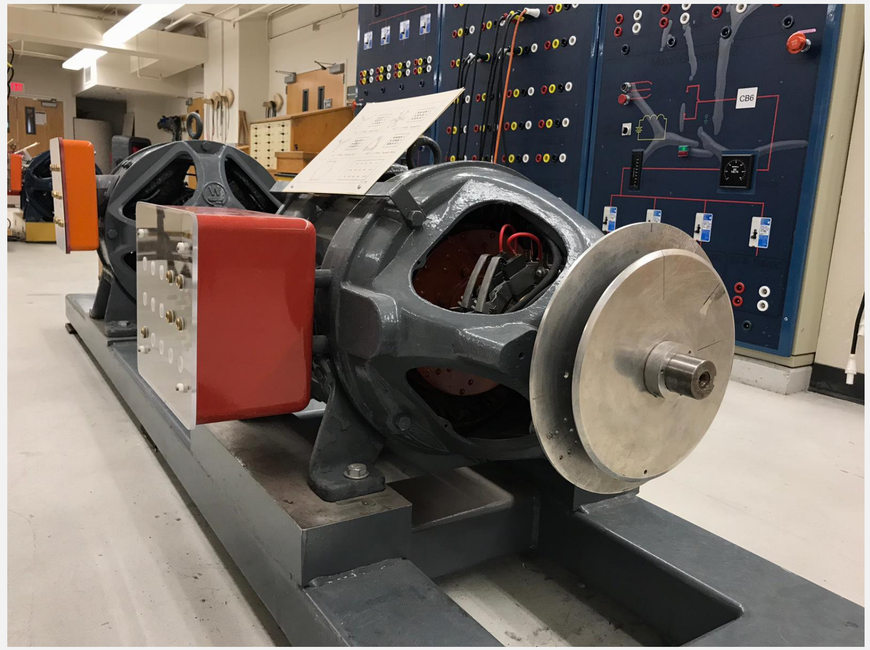
After a fault occurs

- The angle of the generator will increase and may exceed $\delta_{max}$
- The generator may slip a pole.



# Project Goal

Design and implement a system to acquire measurements from a synchronous generator in transient conditions.



# Specification

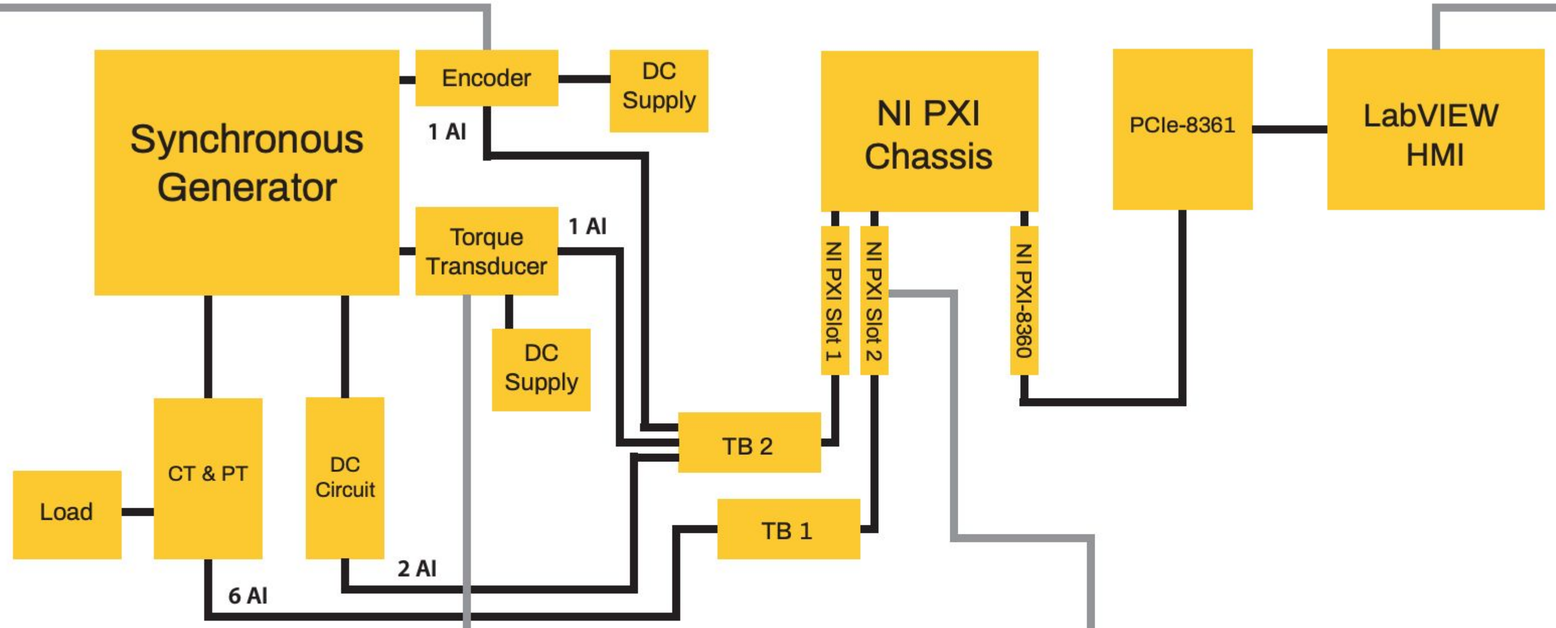
## Measurement Requirements

- Terminal voltage and current
- Field voltage and current
- Torque and power
- Speed and frequency
- Load phase angle

## Device Requirements

- Sampling rate of at least 10 kHz
- Measurements must be time synchronized
- Monitoring and storage of streamed measurements

# System Topology




## Human Machine Interface

We chose National Instruments LabVIEW to capture, store, and stream our measurements for its natual compatibility with other National Instruments hardware.

## Encoder

An encoder is required to measure speed and the Z pulse signal. The encoder we used is the BEI Sensors H25 Incremental Optical Encoder. The Z pulse is used in tandem with the zero crossing of a terminal voltage to calculate the load phase angle.

## Torque Transducer

The Himmelstein MCRT 48202V(1-3) Torque Transducer outputs an analog voltage proportional to the current torque on the shaft. The average torque can be calculated from the peak torque in the induced harmonic.

## Data Acquisition Board

The National Instruments PXI 6251 Data Acquisition Board captures and digitizes analog signals. The PXI chassis then sends the signals to the computer through a PCI connection.

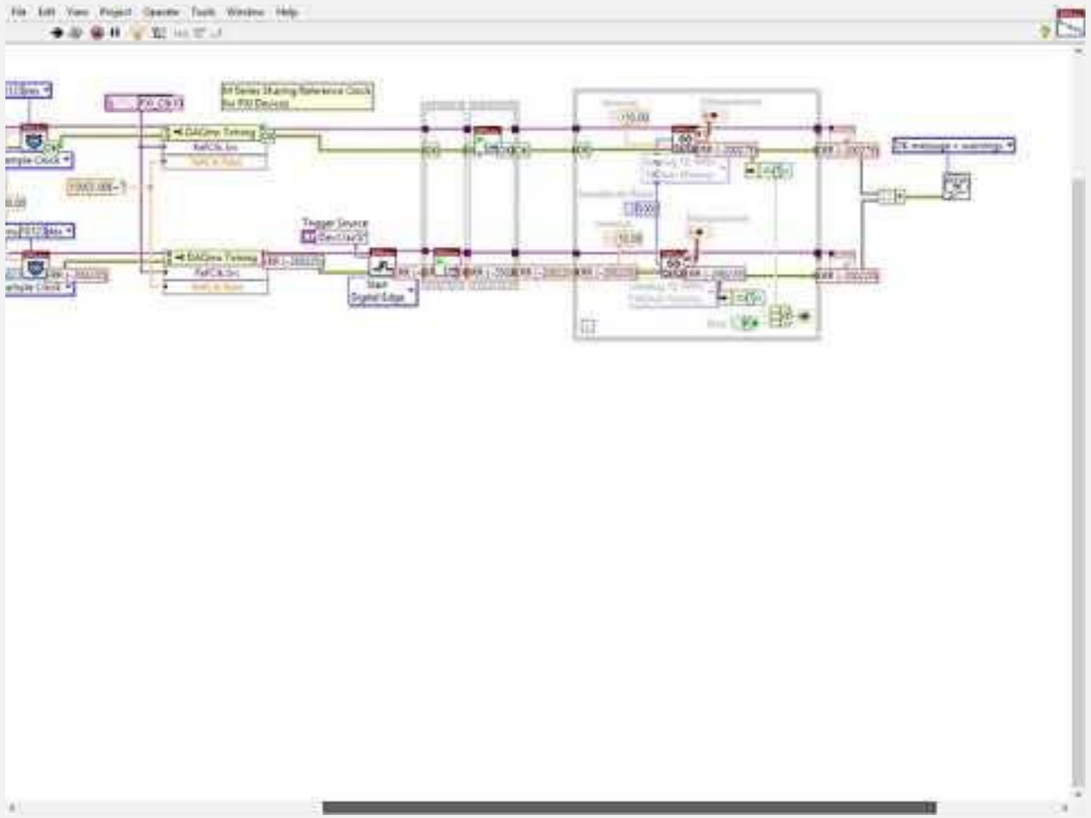
# Data Acquisition Board

# Devices

## National Instruments PXI 6289 & 6251

| | PXI 6289 | PXI 6251 |
|---|---|---|
| Number of Channels | 16 AI | 8 AI |
| ADC resolution | 18 Bits | 16 Bits |
| Sample rate | 500 kS/s | 1 MS/s |

# Synchronizing 2 DAQs



# AC & DC Measurement

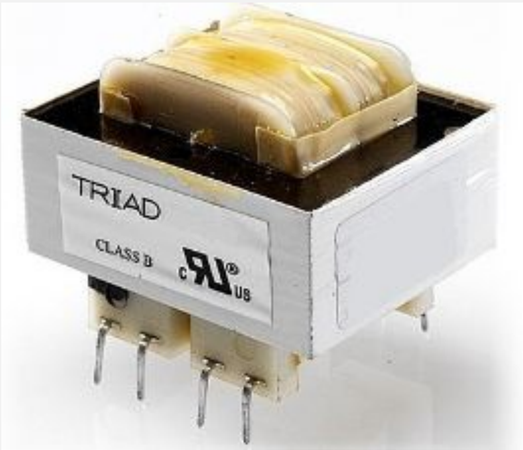
# AC Measurement

| DAQ Acceptable Signal | Generator Rating Voltage | Generator Rating Current | Shunt Resistor for Current Measurement |
|---|---|---|---|
| ± 11V | 220 V | 35.4 A | 1 Ohm<br>50 W |

# AC Measurement

## Potential Transformer

| Model | Rating | Specified Ratio |
|---|---|---|
| FS24-500 | 230V : 12V | 19.2 : 1 |



# AC Measurement

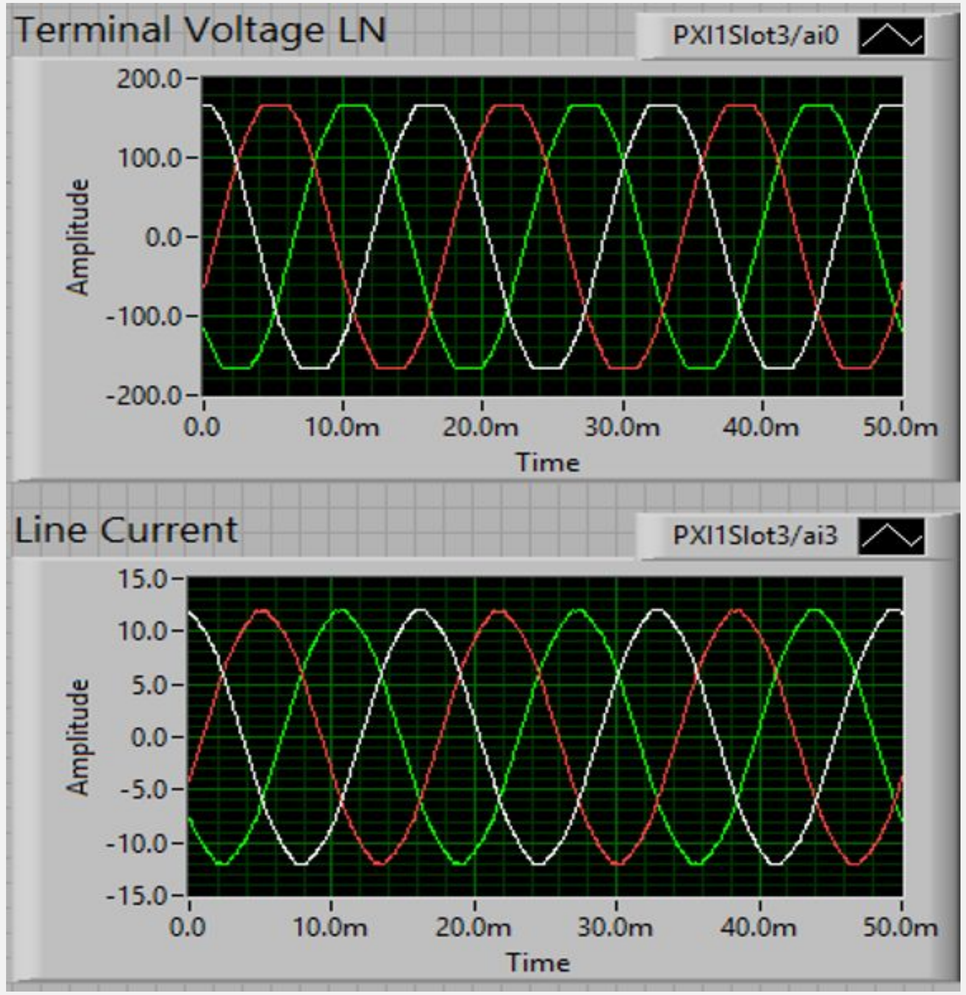
## Current Transformer

| Model | Rating | Ratio |
|---|---|---|
| 114-151 | 150A : 5A | 30 : 1 |

# AC Measurement

## Line to Neutral Voltage and Line Current from LabVIEW

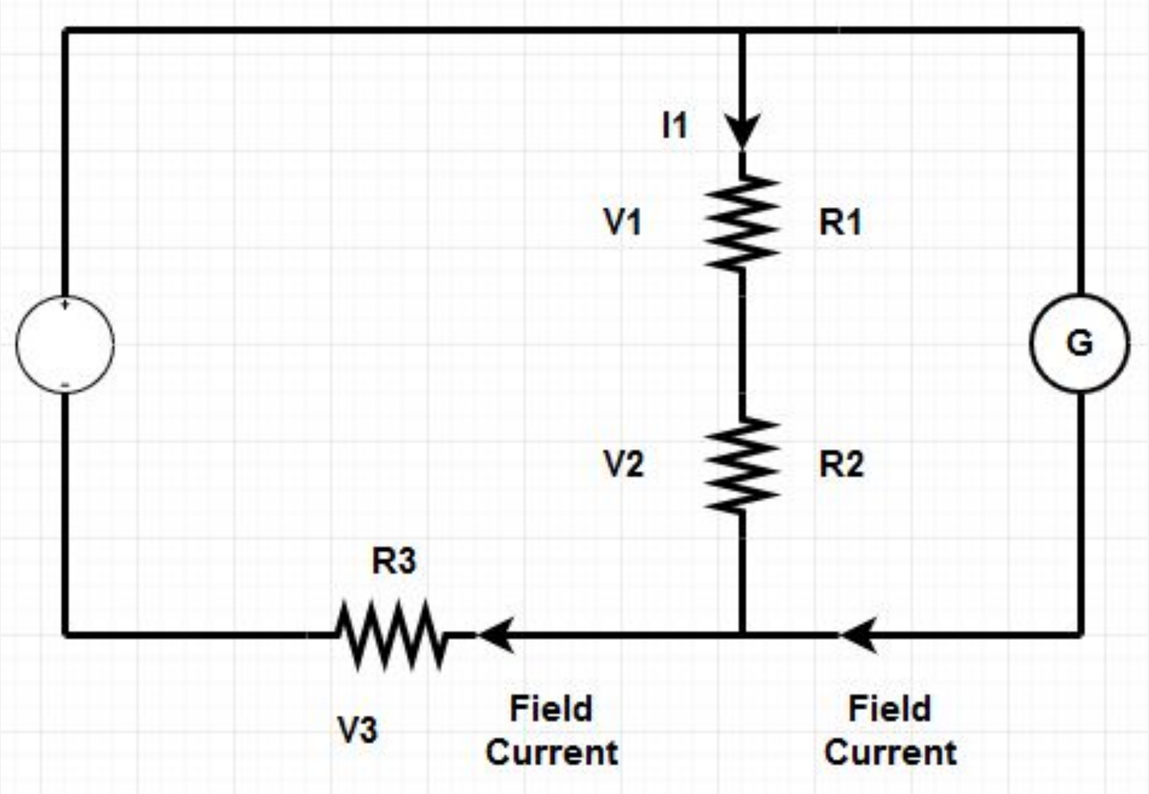
| Rating L-N Voltage | Load | Calculated Line Current |
|---|---|---|
| 127 V RMS<br>179.6V Peak | 14.8Ω | 8.58A RMS<br>12.14A Peak |



# DC Measurement

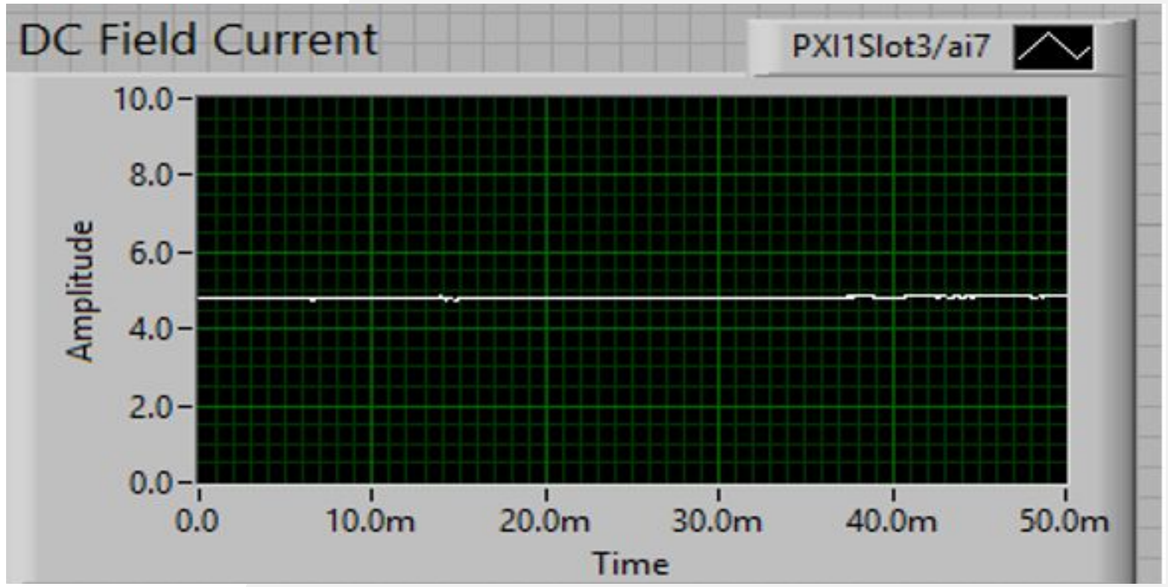
## Circuit for DC Measurement

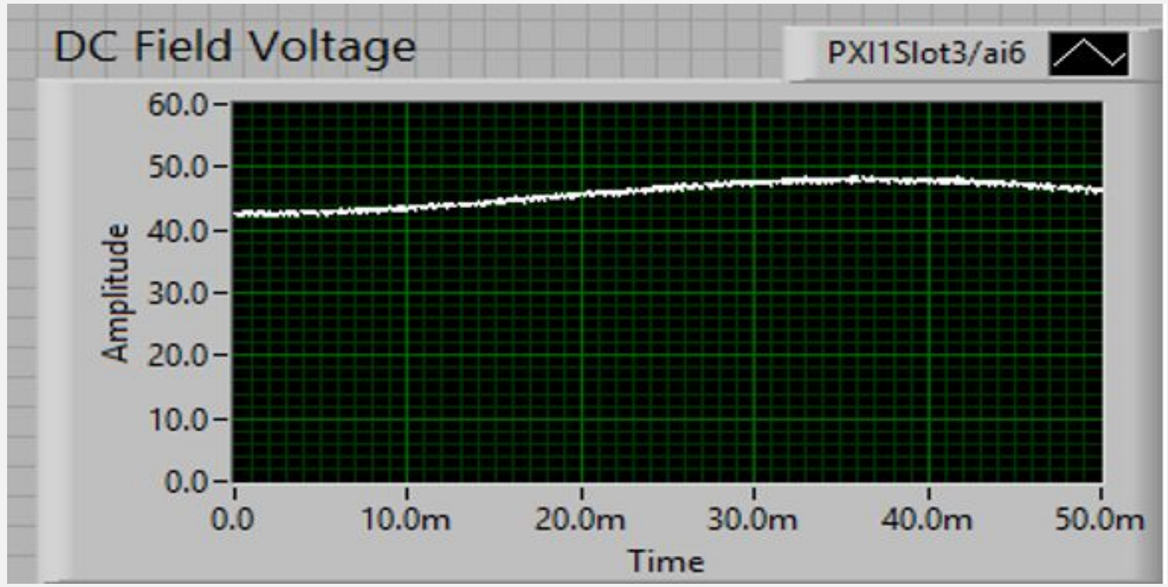
| Shunt Resistor | R1 | R2 | R3 |
|---|---|---|---|
| Resistance | 20kΩ | 1kΩ | 0.1Ω |
| Power Rating | 10 W | 10 W | 50W |



# DC Measurement

## Field Current and Field Voltage from LabVIEW



# Torque Transducer

# Torque Transducer

## Himmelstein MCRT 408202V

Inputs:

- 2-Pin DC Power Supply
- 3-Pin RS232 Digital Communication
- 4-Pin Analog Communication

# Analog Output

## Superimposed Harmonics

Tavg = Tpeak/1.18

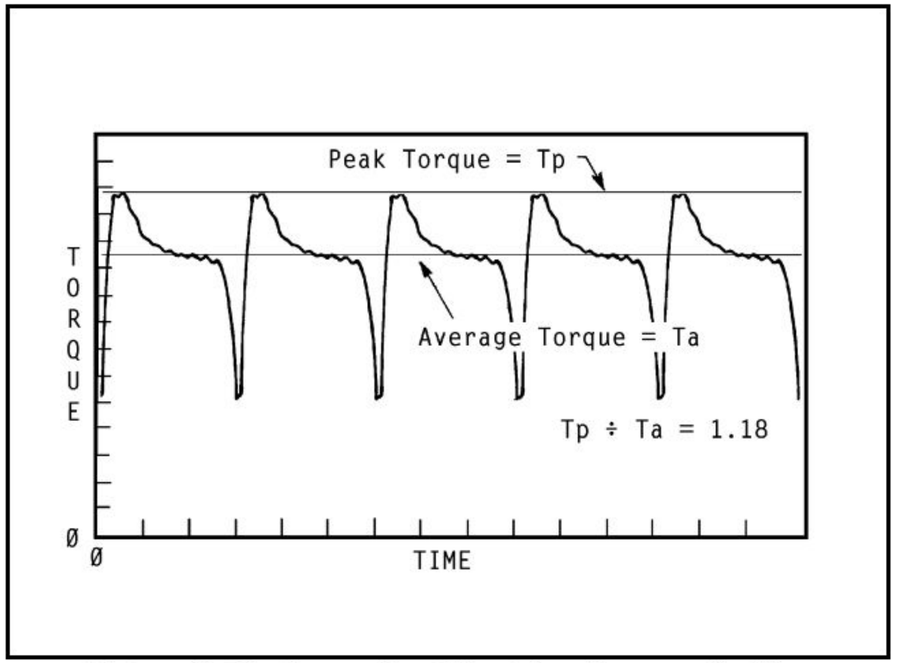



Figure 6. Reciprocating Machine Torque Profile.

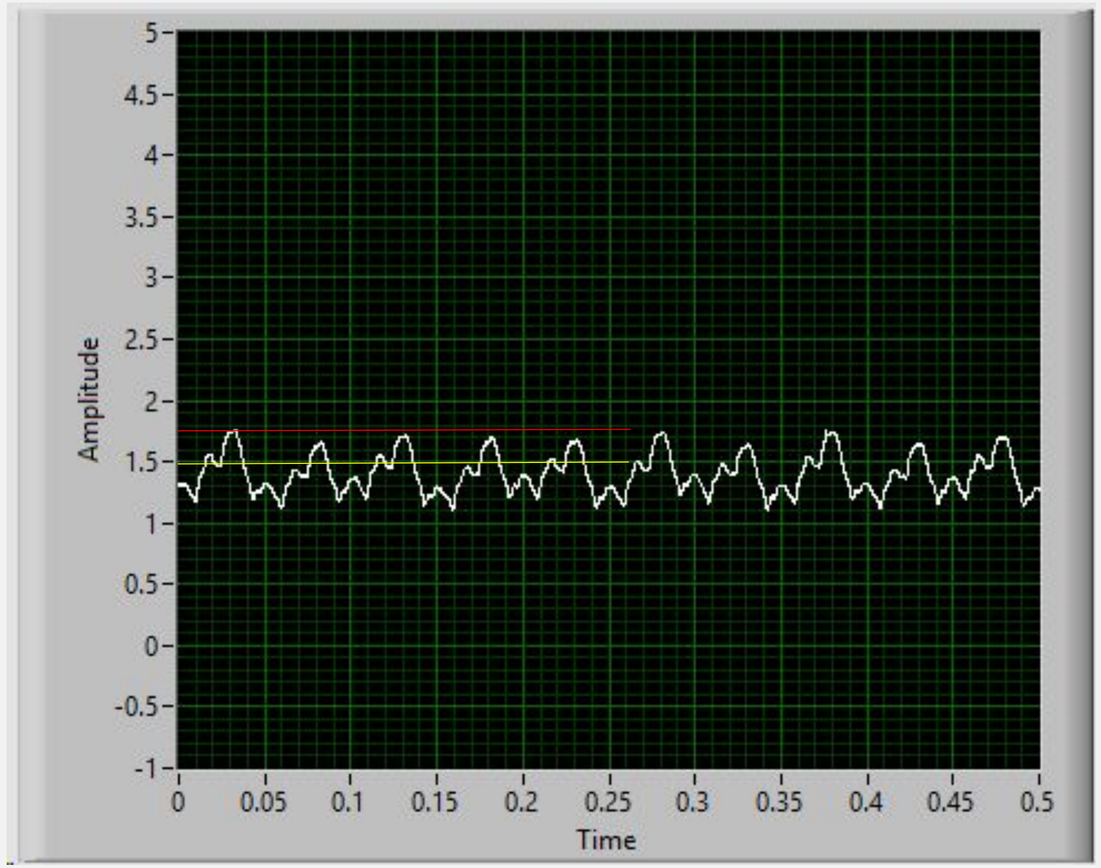
# Analog Output

## Example

Peak ≈ 1.7

Avg ≈ 1.5

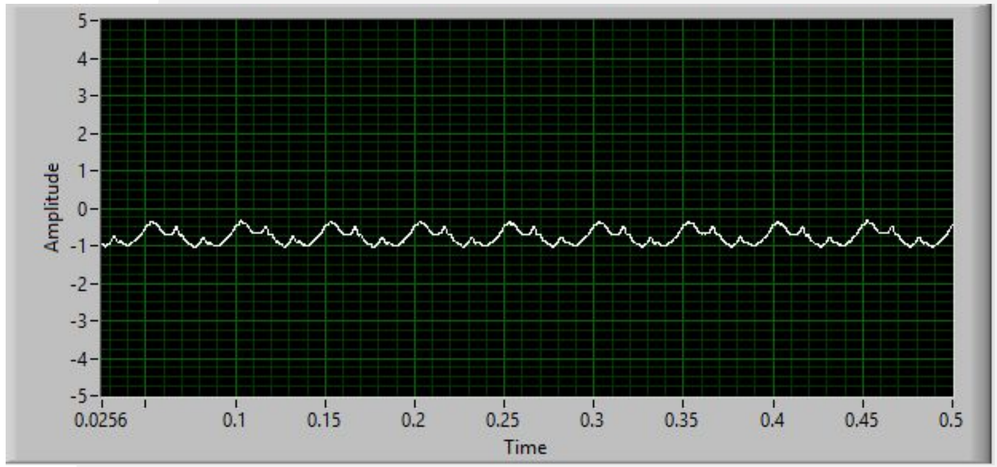
Peak/Avg = 1.13 ≈ 1.18



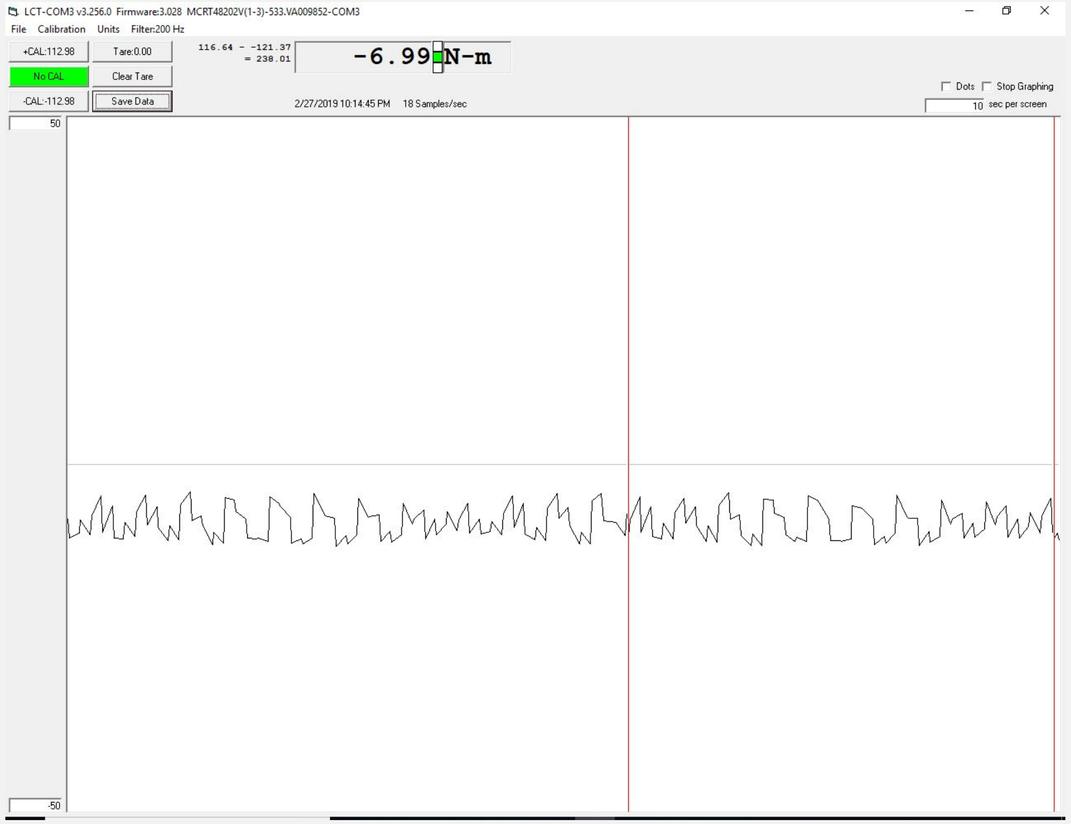
# Analog Output

## Mapping Example

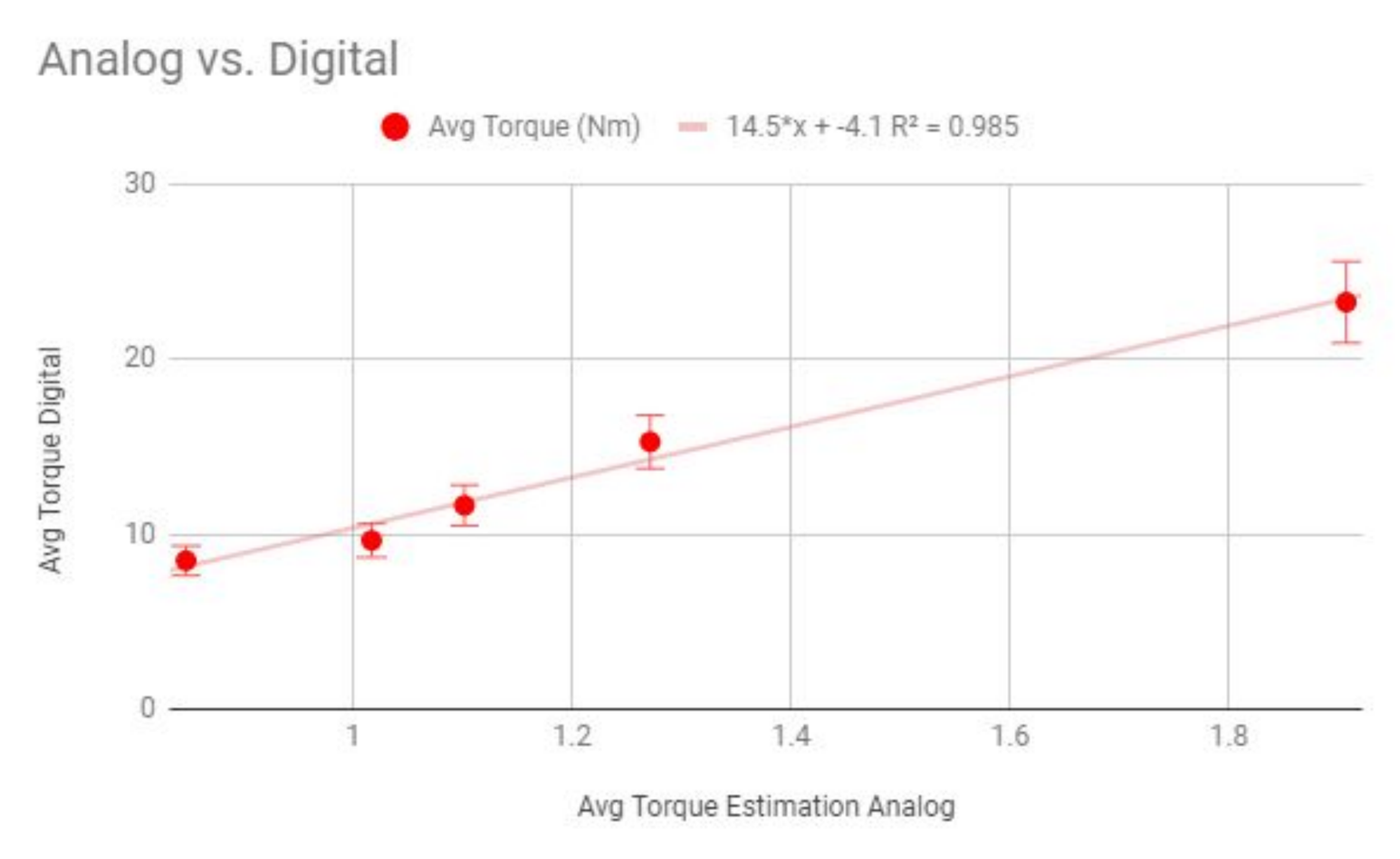
Analog from LabVIEW




Digital from DT482



# Analog Digital Torque Relation



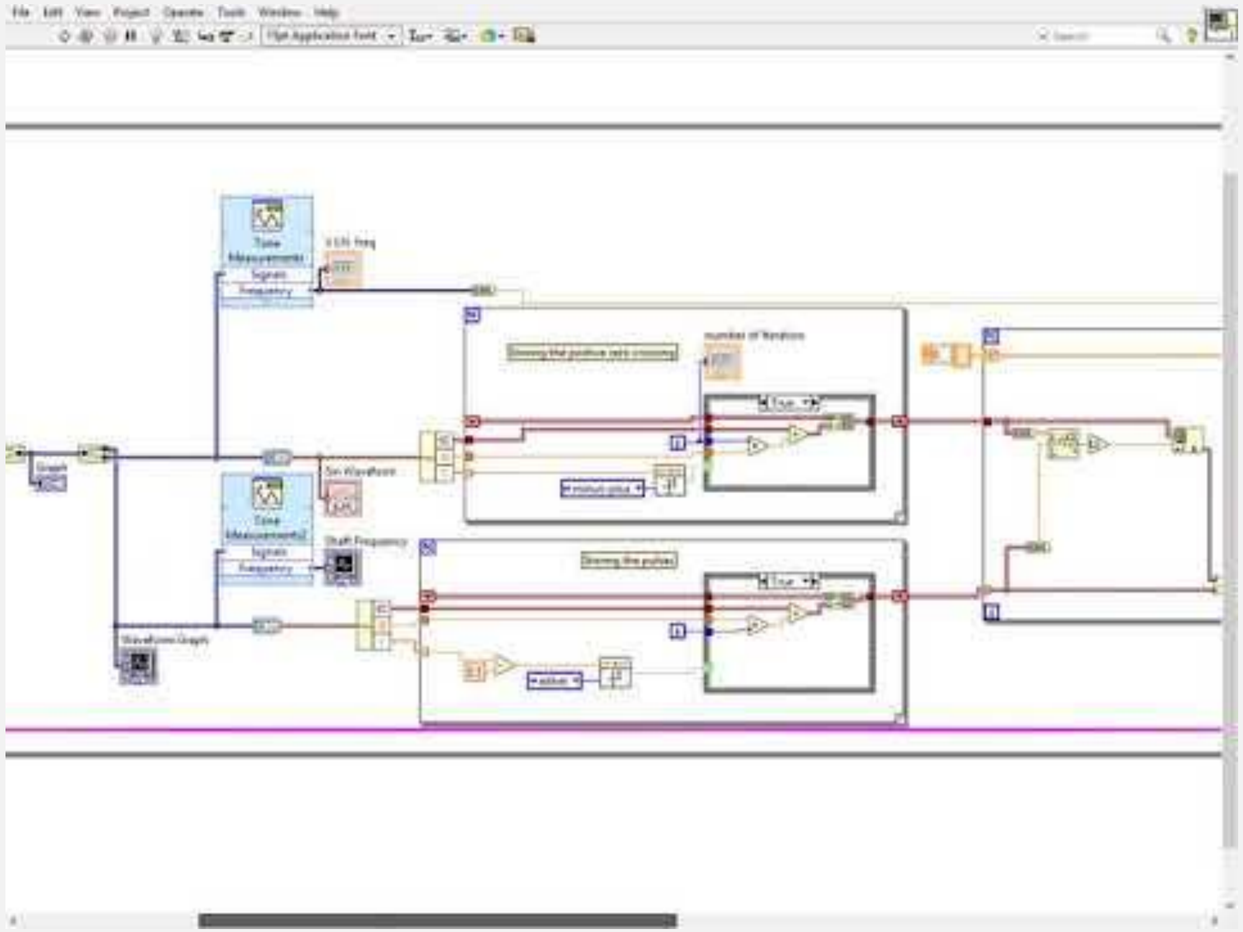
# Encoder

# Encoder

## Type: BEI Sensors H25 Incremental Optical Encoder

- Has three signals: A, B, & Z

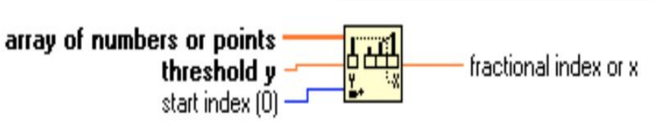
# Load Angle



# Load Angle

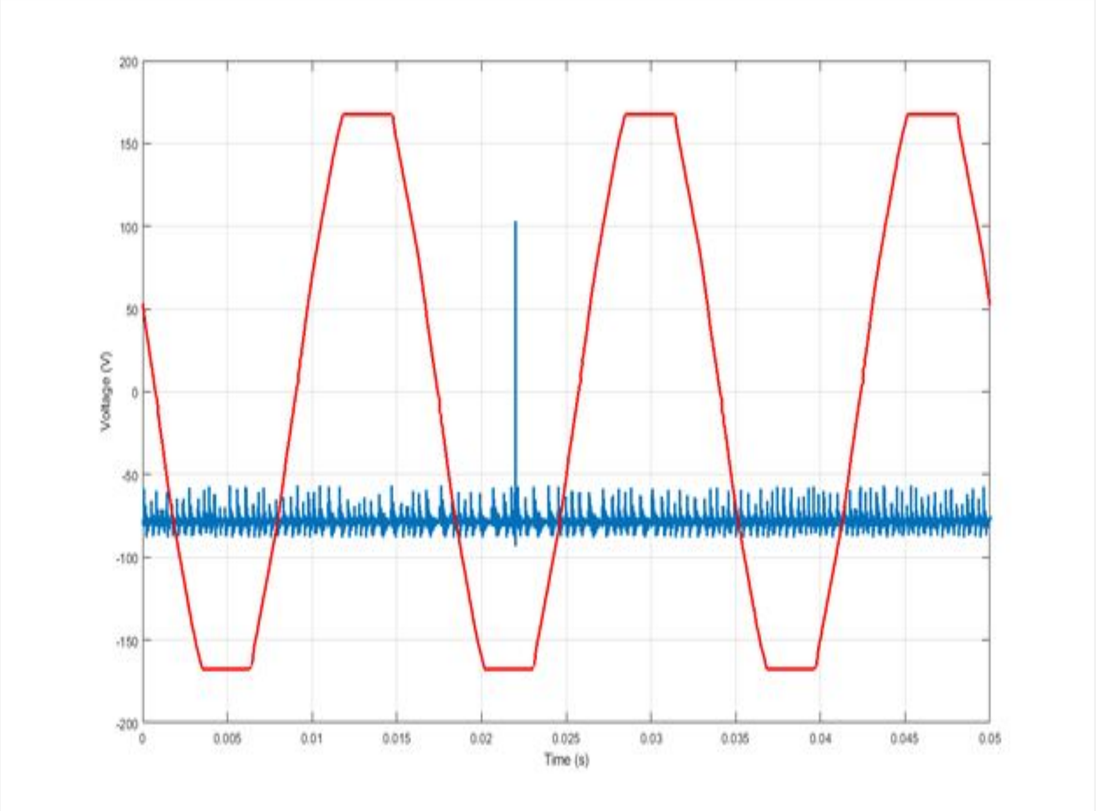
Zero crossing of sine signal = [ 1s  3s  6s ]

Time of pulse signal = [ 4.5s ]

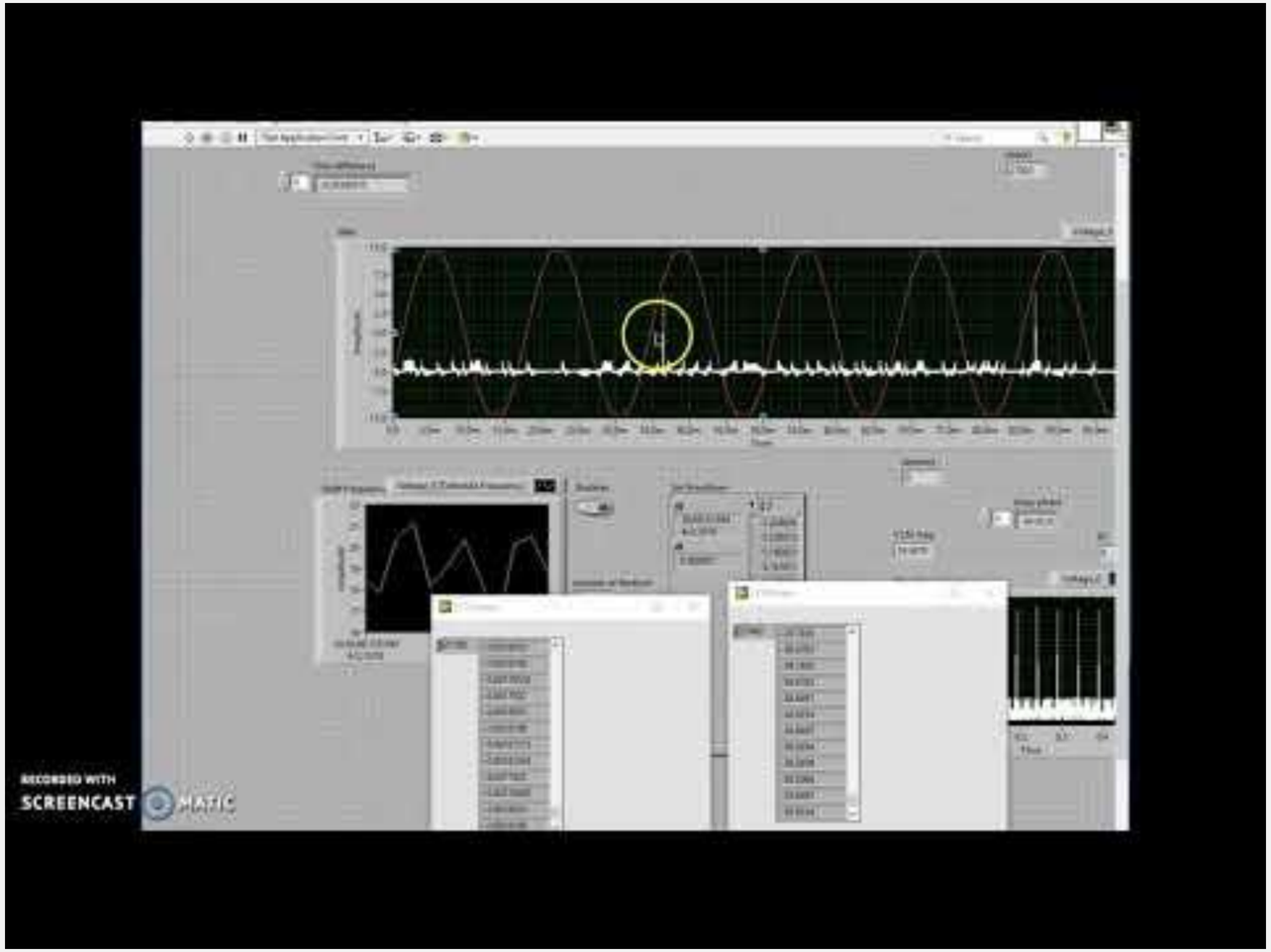



1.5

1



# Load Angle Measurement



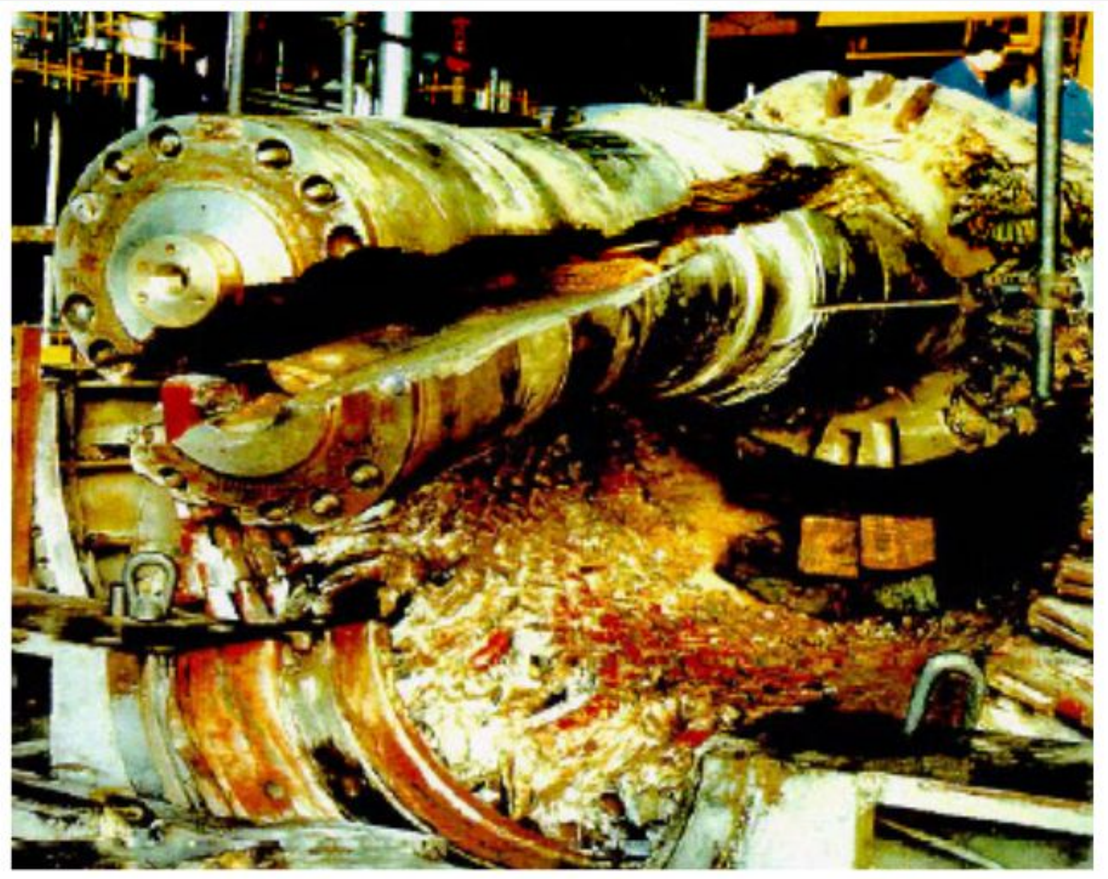
# Budget

**Capstone Project Budget - Fall/Spring**

Project:SEL- Data Acquisition System for Synchronous Generator Transient Performance

Last Updated 4/25/2019

| Expense Items | 2018-2019 | | | | | | | | Item Total |
|---|---|---|---|---|---|---|---|---|---|
| | Sept | Oct | Nov | Dec | Jan | Feb | Mar | Apr | |
| Equipment/Tools: | | | | | | | | | |
| | | | | | | | | | |
| Devices: | | | | | | | | | |
| terminal board 2706 | | | | | | $ 572.4 | | | $ 572 |
| Vishay Dale Resister | | | | | | $ 4.39 | | | $ 4.39 |
| Vishay Dale Resister | | | | | | $ 10.19 | | | $ 10.19 |
| potential transformer | | | | | | $ 39.8 | | | $ 39.8 |
| Torque cable | | | | | | $ 180 | | | $ 180 |
| Shipping fee | | | | | | $ 25 | | | $ 25.04 |
| potential transformer | | | | | | | | $ 66.9 | $ 66.9 |
| Poster | | | | | | | | $ 82.5 | $ 82.5 |
| | | | | | | | | Totals | $ 981.25 |



**Thank you**

**Any Questions?**

# Appendix

## AC Generator Rating Plate

| Rating Power | Rating Voltage | Rating Current | Power Factor | Rating Speed | Rating Field current | Rating Field Voltage |
|---|---|---|---|---|---|---|
| 13.5 kVA | 220 V | 35.4 A | 0.9 | 50 HZ<br>1200 RPM | 8 A | 110 V |

# Appendix

## DC Motor Rating Plate

| Rating Power | Rating Voltage | Rating Current |
|---|---|---|
| 15-18 HP | 115 V | 113-140 A |

# Settling Time for Multichannel Measurements

**Amount of time required for ADC connection to perform multichannel acquisition**

Example: When acquiring data on the NI PXIe-6363 in a +-10V range, the multiplexer must remain on a single channel for up to 1.5 μs for the programmable gain instrumentation amplifier (NI-PGIA) to settle within 1 least significant bit (LSB) of the actual value with a full scale step input provided

# Time Accuracy and Settling Time

| PXI 6289 | | PXI 6251 | |
|---|---|---|---|
| Timing Resolution | Timing Accuracy | Timing Resolution | Timing Accuracy |
| 50 ns | 50 ppm of sample rate | 50 ns | 50 ppm of sample rate |

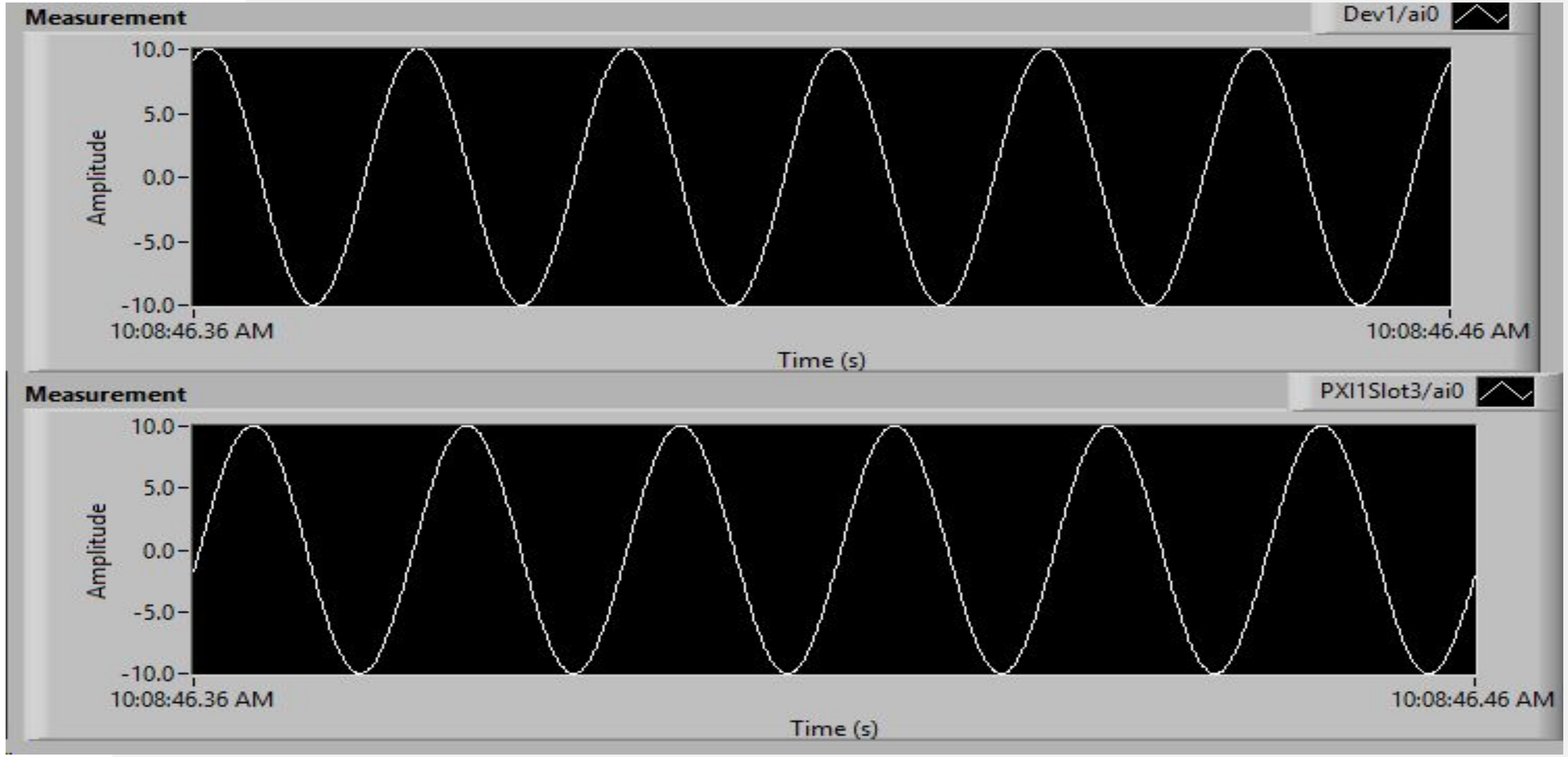
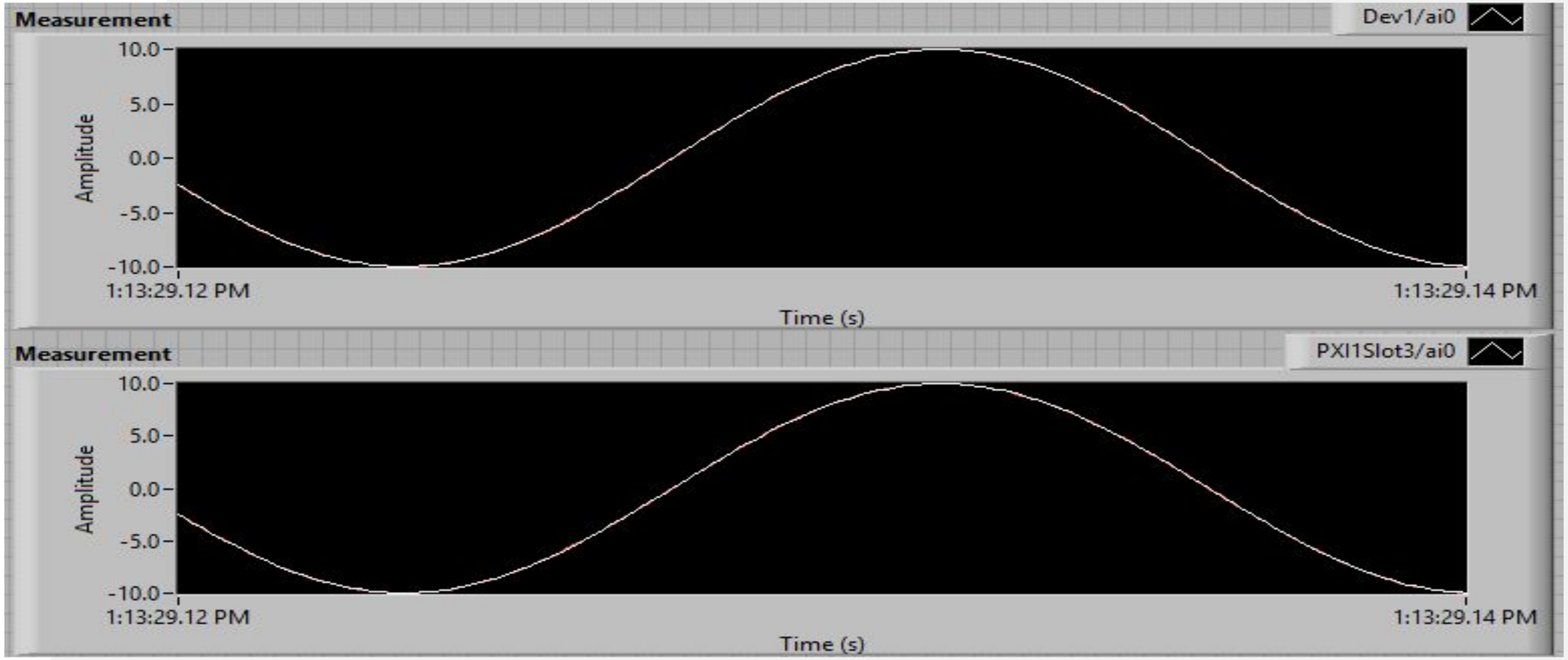
Settling Time for Multichannel Measurements 2 μs

Settling Time for Multichannel Measurements 1us to 1.5 μs

Source :Specifications Explained: NI Multifunction I/O (MIO) DAQ

PXI 6251, PXI 6289 specification

# Synchronizing 2 DAQs



# Synchronizing 2 DAQs